b. All the iron in an ore with mass 1.500 g is converted to Fe^{2+}. The Fe^{2+} ions are made to react with a $K_2Cr_2O_7$ solution. The reaction required 35.25 mL of a 0.05000 M solution of $K_2Cr_2O_7$. The reaction is

$$6\,Fe^{2+}\,(aq) + Cr_2O_7^{2-}\,(aq) + 14\,H^+\,(aq) \rightarrow 6\,Fe^{3+}\,(aq) + 2\,Cr^{3+}\,(aq) + 7\,H_2O$$

Calculate the percent of Fe in the ore. **(E20)**

SELF-TEST

A. Multiple choice:

1. Which of the following substances would precipitate from a mixture of barium, silver, chloride, sulfate, and nitrate ions in aqueous solution?

(1) $BaSO_4$ (2) $BaCl_2$ (3) $Ba(NO_3)_2$ (4) Ag_2SO_4 (5) AgCl

a. (2) **b.** (1),(5) **c.** (1),(2),(3)
d. (1),(2),(4) **e.** (1),(2),(5) **f.** (1),(2),(4),(5)

2. The acid-base reaction between aqueous solutions of HNO_2 and KOH

(1) will produce NO_2 (g) and NO (g).
(2) is a precipitation reaction.
(3) is a weak acid – strong base reaction.
(4) will produce only water.
(5) will produce NO_2^- (aq).

The correct statements are

a. (1),(2) **b.** (1),(3) **c.** (2),(5) **d.** (3),(5) **e.** (3),(4)

3. In which species does sulfur have the same oxidation number as chlorine in ClO_2^-?

a. H_2S **b.** S_8 **c.** SO_3^{2-} **d.** SO_4^{2-} **e.** none of these

4. In an acid-base reaction, the reacting species for $Ba(OH)_2$ is

a. H^+ **b.** OH^- **c.** $(OH)_2^-$ **d.** BaO **e.** Ba^{2+}

5. When NaOH was added to one liter of a solution containing 0.10 mol of each of two metal ions, a precipitate formed with one ion but the other stayed in solution. The solution could have contained

a. Mg^{2+} and Ba^{2+} **b.** K^+ and Ba^{2+} **c.** Mg^{2+} and Cr^{3+}
d. Cr^{3+} and Fe^{3+} **e.** none of these

6. The balanced equation for the reaction between NO_3^- and Br^- in acid is:

$$2\,NO_3^-\,(aq) + 4\,H^+\,(aq) + 2\,Br^-\,(aq) \rightarrow 2\,NO_2\,(g) + Br_2\,(\ell) + 2\,H_2O$$

When this equation is balanced in basic solution, the number of H_2O molecules is

a. 2 on the left **b.** 2 on the right
c. 4 on the left **d.** 4 on the right
e. zero on both sides of the equation

7. Consider the unbalanced equation for the following reaction in acid medium:

$$Se\,(s) + NO_3^-\,(aq) \rightarrow SeO_2\,(s) + NO\,(g)$$

In the balanced, net ionic equation, the smallest whole number coefficients for Se and NO_3^- respectively are

a. 3,4 **b.** 4,3 **c.** 2,4 **d.** 4,2 **e.** 2,3

8. How many of the following anions are derived from strong acids?

Cl^- $C_2H_3O_2^-$ PO_4^{3-} NO_3^- CO_3^{2-}

a. 1 **b.** 2 **c.** 3 **d.** 4 **e.** 5

9. For the reaction

$$Cu\,(s) + 4\,H^+\,(aq) + 2\,NO_3^-\,(aq) \rightarrow 2\,NO_2\,(g) + 2\,H_2O + Cu^{2+}\,(aq)$$

the oxidizing agent and the reducing agent are, in that order:

a. Cu, NO_3^- **b.** Cu, H^+ **c.** H^+
d. H^+, Cu **e.** NO_3^-, Cu

10. The equation for a redox reaction in basic solution

a. always has hydroxide ions as reactant.
b. may have hydroxide ions as either reactant or product.
c. may contain hydrogen ions.
d. always has water as a product.
e. None of the above is true.

B. Writing Equations:

Write balanced net ionic equations using smallest whole number coefficients for the following reactions between 0.1 M aqueous solutions of the following:

1. lead nitrate and sodium chloride

_____

2. perchloric acid and barium hydroxide

_____

3. hydriodic acid and ammonia

_____

4. acetic acid and potassium hydroxide

_____

5. sulfuric acid and barium chloride

_____

6. nickel(II) nitrate and hydrochloric acid

_____

C. Problems:

1. Consider mixing solutions of silver nitrate and calcium chloride.
   a. Write a net ionic equation for the formation of the precipitate, if any.

   b. If 200.0 mL of 0.300 M silver nitrate are mixed with 350.0 mL of 0.500 M calcium chloride, how many grams of precipitate are formed? How many moles of each ion are present after precipitation?

c. What volume of 0.250 M calcium chloride would be required to precipitate silver chloride if it is mixed with 600.0 mL of 0.650 M silver nitrate?

2. Consider two solutions. One solution is 0.1115 M $Ca(OH)_2$. The other is 0.1050 M $HClO_4$.

a. Write a balanced equation for the reaction between the two solutions.

b. How many mL of $Ca(OH)_2$ will be required to neutralize 25.00 mL of the $HClO_4$?

c. If a student starts to titrate 31.39 mL of the $Ca(OH)_2$ solution with $HClO_4$ and stops the titration after only 23.81 mL of $HClO_4$ have been added, then

(1) How many moles of H^+ have been added?

(2) How many moles of OH^- are left unreacted?

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3. Balance the following equations:

a. $S_2O_3^{2-}$ (aq) + I_3^- (aq) → $S_4O_6^{2-}$ (aq) + I^- (aq)

b. Mn^{2+} (aq) + $HBiO_3$ (s) → MnO_4^- (aq) + BiO^+ (aq) (acid)

c. $Cr_2O_7^{2-}$ (aq) + H_3AsO_3 (aq) → H_3AsO_4 (aq) + Cr^{3+} (aq) (acid)

d. ClO^- (aq) + CrO_2^- (aq) → Cl^- (aq) + CrO_4^{2-} (aq) (basic)

e. OBr^- (aq) + HPO_3^{2-} (aq) → Br^- (aq) + PO_4^{3-} (aq) (basic)

4. The salt $KBrO_3$ oxidizes Sn^{2+} to $SnCl_6^{2-}$ in the presence of hydrochloric acid according to the equation

$$3\,Sn^{2+}\,(aq) + 18\,Cl^-\,(aq) + BrO_3^-\,(aq) + 6\,H^+\,(aq) \rightarrow 3\,SnCl_6^{2-}\,(aq) + Br^-\,(aq) + 3\,H_2O$$

A sample weighing 2.000 g is dissolved in acid and all the tin present is converted to Sn^{2+}. For the reaction to go to completion, 32.50 mL of a 0.07500 M $KBrO_3$ solution are required. Find the percent of tin in the sample.

ANSWERS

Exercises:

(E1) 102 mL **(E2)** 1.402 M

(E3) 0.0912 M Na^+, 0.0304 M N^{3-}, 0.128 M Sc^{3+}, 0.384 M Cl^-

(E4) (1) A precipitate of barium sulfate forms. (2) No precipitate forms.

(E5) $3\,Zn^{2+}\,(aq) + 2\,PO_4^{3-}\,(aq) \rightarrow Zn_3(PO_4)_2\,(s)$

(E6) 10.0 g **(E7)** 0.161 M

(E8) $C_6H_5NH_2\,(aq) + H^+\,(aq) \rightarrow C_6H_5NH_3^+\,(aq)$

(E9) $H^+\,(aq) + OH^-\,(aq) \rightarrow H_2O$

(E10) $HC_6H_7O_6\,(aq) + OH^-\,(aq) \rightarrow C_6H_7O_6^-\,(aq) + H_2O$

(E11) 0.02058 M **(E12)** 0.4202 g **(E13)** 3.34 %

(E14) 0.0119 M

(E15) In NO_2: N has oxidation number +4 and O has oxidation number -2.
In NH_4^+: N has oxidation number -3 and H has oxidation number +1.

(E16) oxidizing agent - MnO_4^-; reducing agent - NO_2^-

(E17) reduction half-reaction: $PbO\,(s) + 2\,e^- + H_2O \rightarrow Pb\,(s) + 2\,OH^-\,(aq)$

oxidation half-reaction: $2\,NH_3\,(g) + 6\,OH^-\,(aq) \rightarrow N_2\,(g) + 6\,e^- + 6\,H_2O$

(E18) acid: $4\,Cl_2\,(g) + S_2O_3^{2-}\,(aq) + 5\,H_2O \rightarrow 8\,Cl^-\,(aq) + 2\,SO_4^{2-}\,(aq) + 10\,H^+\,(aq)$

base: $4\,Cl_2\,(g) + S_2O_3^{2-}\,(aq) + 10\,OH^-\,(aq) \rightarrow 8\,Cl^-\,(aq) + 2\,SO_4^{2-}\,(aq) + 5\,H_2O$

(E19) 0.150 M **(E20)** 39.37 %

Self-Test

A. Multiple Choice:

1. b	**2.** d	**3.** e	**4.** b	**5.** a
6. a	**7.** a	**8.** b	**9.** e	**10.** b

B. Writing Equations:

1. $Pb^{2+}(aq) + 2\,Cl^{-}(aq) \rightarrow PbCl_2(s)$

2. $H^{+}(aq) + OH^{-}(aq) \rightarrow H_2O$

3. $H^{+}(aq) + NH_3(aq) \rightarrow NH_4^{+}(aq)$

4. $HC_2H_3O_2(aq) + OH^{-}(aq) \rightarrow H_2O + C_2H_3O_2^{-}(aq)$

5. $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

6. no reaction

C. Problems:

1. a. $Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$

b. 8.60 g AgCl; 0.00 mol Ag^{+}; 0.290 mol Cl^{-}; 0.175 mol Ca^{2+}; 0.0600 mol NO_3^{-}

c. 0.780 L

2. a. $H^{+}(aq) + OH^{-}(aq) \rightarrow H_2O$

b. 11.77 mL

c. (1) 2.500×10^{-3} mol H^{+} (2) 4.500×10^{-3} mol OH^{-}

3. a. $2\,S_2O_3^{2-}(aq) + I_3^{-}(aq) \rightarrow S_4O_6^{2-}(aq) + 3\,I^{-}(aq)$

b. $5\,HBiO_3(s) + 2\,Mn^{2+}(aq) \rightarrow 2\,MnO_4^{-}(aq) + 5\,BiO^{+}(aq) + 2\,H_2O + H^{+}(aq)$

c. $Cr_2O_7^{2-}(aq) + 3\,H_3AsO_3(aq) + 8\,H^{+}(aq) \rightarrow 2\,Cr^{3+}(aq) + 3\,H_3AsO_4(aq) + 4\,H_2O$

d. $3\,ClO^{-}(aq) + 2\,CrO_2^{-}(aq) + 2\,OH^{-}(aq) \rightarrow 3\,Cl^{-}(aq) + 2\,CrO_4^{2-}(aq) + H_2O$

e. $OBr^{-}(aq) + HPO_3^{2-}(aq) + OH^{-}(aq) \rightarrow Br^{-}(aq) + PO_4^{3-}(aq) + H_2O$

4. 43.40 %